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NEW RADIAL VELOCITIES FOR DWARF GALAXIES IN THE LOCAL VOLUME

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Radial velocities measured with the 6-meter telescope are given for 5 faint dwarf galaxies. All of these galaxies are confirmed as very nearby objects. Two of them, KK135 (dIr) and UGC 1703 (dSph/dTr), are local isolated dwarfs, and the three others, UGCA 127sat (dIr), NGC 2683dw1 (dIr), and NGC891dwA (dTr), belong to companions of nearby massive spirals.
Keywords: *galaxies: radial velocities*

1. Introduction

In the astronomical literature there are a number of catalogs of galaxies which are organized in terms of a limiting flux of the objects in the optical and infrared ranges, or in terms of the flux in the 21 cm radio line [1–4]. Kraan-Korteweg and Tammann [5] provided a justification for a catalog based on distance, rather than flux (apparent magnitude). The need for a representative sample of nearby galaxies within a fixed volume is dictated as well by the need to compare various "mock" catalogs produced by numerical modelling of large-scale structures of the universe [6,7] with observational data. The catalog of Ref. 5 enumerated a total of 179 galaxies with expected distances within a range of 10 Mpc. The obvious difficulty of creating such a catalog arose from the absence at that time of reliable distance estimates, even for the closest and brightest galaxies. The situation has changed fundamentally over the last two decades, when bulk distance measurements began to be made with the Hubble telescope. The progress of these measurements, which are based on the luminosity of stars at the top of the red giant branch, is illustrated in the Catalog of Neighboring Galaxies, CNG [8], and in the Extragalactic Distance Database, EDD [9]. The revised and supplemented UNGC catalog [10] contains 869 galaxies, or almost five times the number in the original sample [5]. The UNGC catalog includes galaxies with radial velocities $V_{LG} < 600$ km/s relative to the centroid of the Local group, or galaxies with individual estimated distances $D < 11$ Mpc.

At the time the UNGC was published (2013), half of the galaxies in the catalog of distances were measured with an accuracy of better than 10%. At the same time, data on radial velocity are lacking for 108 of the galaxies (12% of the sample). Most of these are distinguished by a low surface brightness, and do not contain HII regions or a significant amount of neutral hydrogen. Objects of this sort with old star populations usually occure near highly luminous galaxies subject to gas sweeping from the shallow potential well of a dwarf as it interacts with a massive neighbor. In recent years, there has been a rapid increase in the number of galaxies with low surface brightnesses in the Local volume ($D < 11$ Mpc) because of targeted searches for dwarf companions around massive nearby galaxies, which can be photographed with small-diameter telescopes but with very long exposure times [11–13].

Among the dwarf galaxies without radial velocities there are a few that are not associated with bright galaxies. The UNGC catalog contains a total of 17 such objects. Two of these, KK 258 and KKs3, turn out to be very nearby, isolated systems at distances of ∼2 Mpc [14, 15]. Measurement of the radial velocities of this small category of galaxies is an important step toward understanding their nature. We emphasize that the origin of isolated dwarf spheroidal(dSph) galaxies has not yet been explained convincingly in modern cosmological models.

2. Observations and data processing

At the Special Astrophysical Observatory of the Russian Academy of Sciences, spectral observations have been made on the 6-meter telescope of galaxies within the Local volume for which the radial velocities have not been estimated before. The SCORPIO universal focal reducer was used in the "long slit" mode [16] with a spectral resolution of ∼ 10Å/pixel. Table 1 is a list of the observed galaxies, each with an observation date, exposure time, average seeing, and the diffraction grating that was employed.

The spectra recorded with the CCD were reduced in the standard MIDAS system using the LONG package. The radial velocity of an object was determined in two ways: by measuring individual emission or absorption lines and by cross correlation with a reference spectrum.

The results of our observations are listed in Table 2. The first and second columns give the name of the galaxy and its coordinates at the epoch J2000.0, and the third through seventh columns give the integrated B magnitude, morphological type, absolute magnitude, and the heliocentric radial velocity and the corresponding measurement error.

Table 1: Observation Log

Galaxy	Date	Exposure (s)	Seeing ″	Grating
KK135	25.02.2015	2 x 1200	1.7	VPHG550G
UGCA 127 sat	28.10.2014	300, 900	1.3	VPHG1200B
UGC1703	26.10.2014	4 x 1200	1.2	VPHG1200B
UGC1703	28.10.2014	8 x 1200	1.1	VPHG1200B
NGC 2683 dw1	29.10.2014	2 x 900	0.9	VPHG1200B
[TT2009]25	19.02.2015	3 x 1200	3.0	VPHG1200G
NGC672 dwD	23.01.2015	2 x 600	1.0	VPHG1200R

Table 2: Parameters of the Observed Galaxies

Galaxy	RA (J2000.0) Dec	B mag	Type	M_B	V_h km/s	σ_V km/s
KK 135	121934.7+580234	18.1	dIr	-10.2	215	40
UGCA 127 sat	062054.8–083901	16.9	dIr	-16.3	708	26
UGC 1703	021255.8+324851	17.0	dSph	-11.5	40	20
NGC 2683 dw1	085326.8+331820	19.5	dIr	-12.0	380	25
[2009]25	022112.4+422150	17.9	dTr	-12.3	692	58
NGC 672 dwD	014738.4+272620	18.7	S	-19.6	29860	110

3. Discussion of results

Here we briefly note some features of the observed galaxies.

3.1. KK 135=PGC 166130=SDSS J121934.68+580234.4. This irregular dwarf galaxy with an angular size of $0.68' \times 0.35'$ was reported in Ref. 17, but not included in the UNGC catalog because the radial velocity had not been measured. In the ultraviolet sky survey GALEX [18] it has apparent magnitudes of $m(FUV) = 18.70 \pm 0.12$ and $m(NUV) = 18.60 \pm 0.04$. An image of this galaxy from the Sloan Digital Sky Survey [19] is shown in Fig. 1. A reproduction of the spectrum of KK 135 obtained by us in the 4000-7000Å range is shown in Fig. 2. Judging from the measured radial velocity $V_h = 215 \pm 40$ km/s, this galaxy certainly belongs to the Local volume sample. A compact HII region lies on the southern side of KK 135. KK 135 is an extremely isolated galaxy. Another irregular galaxy DDO 123 lies in its neighborhood at an angular separation of 0.9°, but that galaxy has a radial velocity $V_h = 722$ km/s and is at a distance of $D = 10.5$ Mpc [10], so there is no physical coupling of these systems.

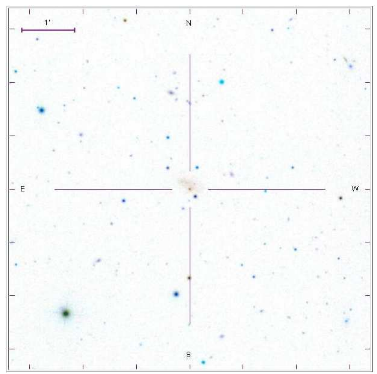

Figure 1: A reproduction of the dwarf galaxy KK 135 from the SDSS survey.

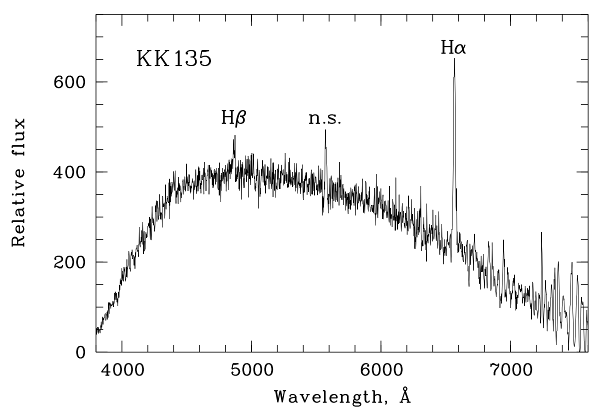

Figure 2: Spectrum of the dwarf galaxy KK 135.

3.2. UGCA 127 sat=LV J0620-0839. This dIr galaxy lies in a zone of strong galactic absorption ($A_b = 3.53^m$) 10′ to the south of the spiral galaxy UGCA 127. Bright emission lines can be seen in the spectrum

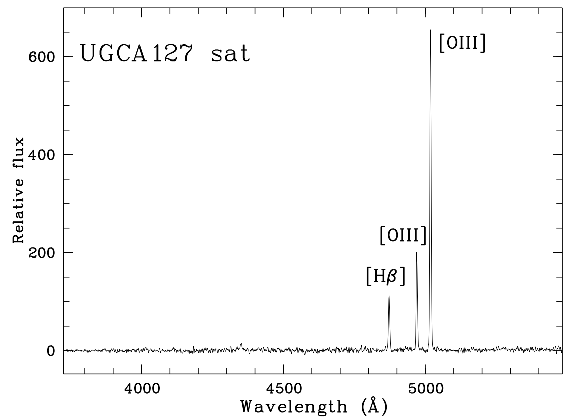

Figure 3: Spectrum of the dwarf galaxy UGCA 127 sat.

of this presumed dwarf companion (Fig. 3); from these we measured a radial velocity for the companion of $V_h = 708 \pm 26$ km/s, which is close to the velocity of the neighboring spiral galaxy, $V_h = 732$ km/s, and confirms the physical coupling of the two. To the east of UGCA 127 sat, there is an emission node [20] with a radial velocity 80 km/s higher than that of the central part of the galaxy.

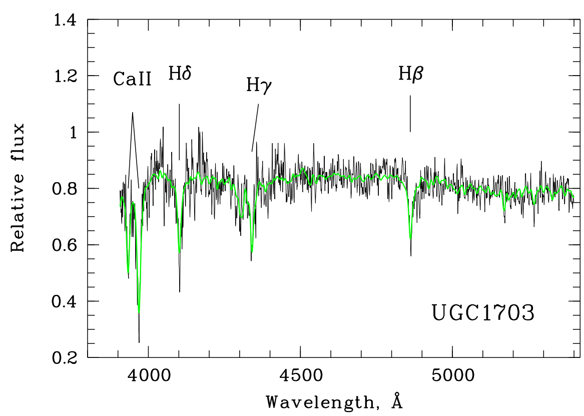

Figure 4: Spectrum of the dwarf galaxy UGC 1703.

3.3. UGC 1703 = KKH 9 = PGC 08484. This is a dwarf galaxy of spheroidal (dSph) or transition (dTr) type. The distance $D = 4.19$ Mpc to it has been estimated from the fluctuations in its surface brightness [21]. In an H_α line trace [22] it shows no signs of emission. Absorption H_β, H_γ , and H_δ Balmer lines and the CaII (H, K) doublet with an average radial velocity of +40 km/s can be seen in its spectrum (Fig. 4).

For this distance the absolute magnitude of UGC 1703 is $M_B = -11.5^m$. This galaxy belongs to a rare class of isolated dwarf systems with an old star population. Its nearest massive neighbor is the spiral galaxy Maffei 2.

3.4. NGC 2683 dw1. This faint, irregular galaxy was discovered in an image of the neighborhood of NGC 2683 obtained using a small telescope by M. Elvov with an exposure of 15 hours [23]. It was detected in the

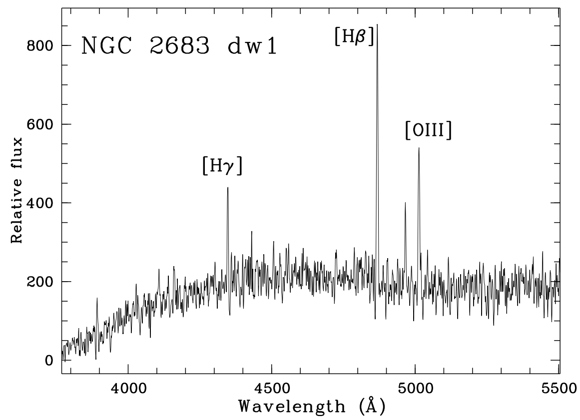

Figure 5: Spectrum of the dwarf galaxy NGC 2683 dw1.

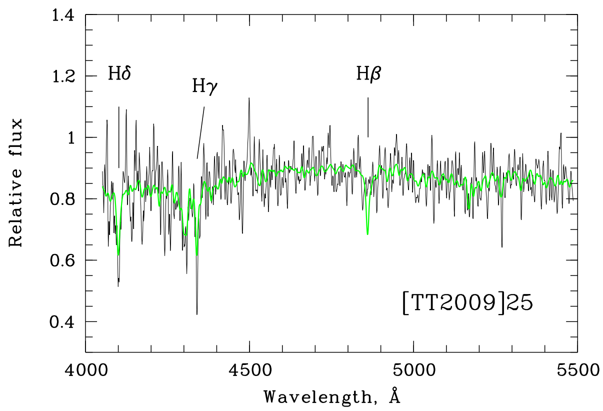

Figure 6: Spectrum of the dwarf galaxy [TT2009]25, companion of NGC 891.

GALEX survey [18] as a faint UV source. Its spectrum (Fig. 5) contains [OIII], H_β, and H_γ emission lines, which imply a radial velocity for the dwarf object of $V_h = 380 \pm 25$ km/s. This confirms that it is physically coupled to the spiral galaxy NGC 2683, which has a velocity Vh = 411 km/s and a distance of 9.36 Mpc [24]. Therefore, NGC 2683 dw1 is a new representative of the galaxies of the Local volume.

3.5. [TT2009]25 = NGC 891 dwA. This is one of two dwarf galaxies with low surface brightnesses discovered [23] in the neighborhood of the spiral galaxy NGC 891. Even earlier it was noted as a probable companion of NGC 891 in a survey with the MegaCam on the 3.6-meter CFHT telescope [25]. Judging from the smooth structure and the presence of a faint UV flux, [TT2009]25 can be classified as a dwarf system of type dTr, intermediate between dSph and dIr. Only absorption lines show up in its spectrum; this indicate a heliocentric velocity for this galaxy of 692 ± 58 km/s, which is consistent with its status as a companion of the spiral NGC 891, for which $V_h = 526$ km/s.

3.6. NGC 672 dwD. During a search for new companions surrounding nearby massive galaxies [23], a faint bluish compact object with a visible magnitude of $B = 18.7^m$ was noticed. We obtained its spectrum and found that it is actually a distant spiral galaxy with radial velocity $V_h = 29860 \pm 110$ km/s.

4. Concluding comment

Searches for new ultrafaint companions around nearby massive galaxies by amateur astronomers with small telescopes are extremely important for the cosmology of the Local universe. This program augments the sample of "test particles" in the Local volume, so that the distribution of the gravitational potential can be tested on small scales with an unprecedented high density of data. Bulk searches for candidate members of the Local volume must obviously be accompanied by measurements of their radial velocities on large telescopes. The combined efforts of amateur astronomical photographers and professional astronomers promise great advances in the study of the Local velocity field of galaxies. This work was supported by a grant from the Russian Science Foundation (project No. 14–12–00965).

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